Lagrangian Floats for Deep Convection

Eric A. D'Asaro
APL/UW 1013 NE 40th Str, Seattle, WA 98105
phone: (206) 685-2982 fax: (206) 543-6785 email: dasaro@apl.washington.edu

Grant Number: N000149410025
http://poseidon.apl.washington.edu/~dasaro/HOME/

LONG-TERM GOALS

I aim to understand the process of deep convection in the ocean.

OBJECTIVES

Near surface water is mixed to great depth at a few high latitude locations, thereby forming the deep and bottom masses of the ocean. This proposal has supported the development and deployment of neutrally buoyant floats in the Labrador Sea in the winters of 1997 and 1998 and the analysis of the resulting data. These floats provide detailed information on the processes and rates of deep convection. A no-cost extension during FY02 allowed further analysis of the data.

APPROACH

Lagrangian Floats (see figure) accurately follow water motions through a combination of a density which matches that of seawater and a high drag. The density is matched to that of the ambient water by actively changing the float's volume and will stay matched, despite changes in pressure and temperature, though a combination of active control and a hull compressibility which is close to that of seawater. High drag is achieved through a large circular cloth drogue attached to the float. The horizontal motion of the float is determined by acoustic tracking (RAFOS) and its vertical motion is determined from pressure. Data is relayed at the end of the 2-month mission via satellite (ARGOS). These data are supplemented by meteorological and oceanographic data from other investigators involved in the Labrador Sea Deep Convection experiment.

WORK COMPLETED

Our data from both 1997 (13 floats) and 1998 (7 floats) has been completely processed and calibrated and the basic data analysis completed. Two papers have been published in a special Labrador Sea Convection issue of the *Journal of Physical Oceanography*, one describing the floats and data and a second, with Ramsey Harcourt of NPS, comparing these with the predictions of an LES model. A third paper has been submitted to the *Journal of Physical Oceanography* describing the small scale eddy structure of convection. A fourth, describing plume-scale eddies, will complete graduate student Elizabeth Steffen's Ph.D. thesis.

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14. ABSTRACT
Near surface water is mixed to great depth at a few high latitude locations, thereby forming the deep and bottom masses of the ocean. This proposal has supported the development and deployment of neutrally buoyant floats in the Labrador Sea in the winters of 1997 and 1998 and the analysis of the resulting data. These floats provide detailed information on the processes and rates of deep convection. A no-cost extension during FY02 allowed further analysis of the data.

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RESULTS

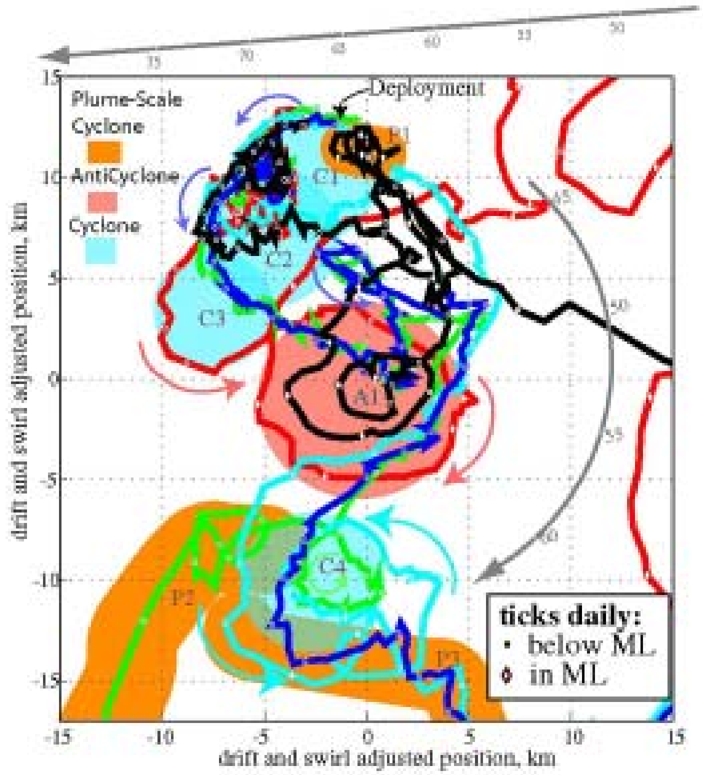

Figure 1. Lagrangian float trajectories (colored lines) during deep convection reveal a complex eddy structure consisting of both 5 km anticyclones (red) and cyclones (blue) and 1 km cyclones (orange). Coordinate system has been translated horizontally (top gray diagonal line) and rotated (gray arc) to enhance the features. Lines are labeled with amount of rotation and advection on each day of 1998.

Figure 1 shows the small-scale structure of convection revealed by the trajectories of the 1998 Lagrangian floats. A rich structure of cyclonic and anti-cyclonic eddies is seen on the 5-10 km scale. These eddies disperse the floats horizontally at a rate comparable to that needed to explain the observed large-scale horizontal diffusivity. All but one of the floats end up in 1 km scale cyclones, similar to the "plumes" expected from numerical simulations. This suggests that cyclonic vorticity is cascading to small scales and thus offers an explanation as to why observations on larger scale observe a dominance of anticyclonic eddies.

The eddies appear to have little relationship to the convection, as it occurs nearly homogeneously throughout the region. They are also much too weak to significantly distort the convection or create ``slant" convection, as has been speculated theoretically.

IMPACT/APPLICATIONS

These data have produced direct confirmation of the existing theoretical ideas about how the "rapid mixing" phase of deep convection works. This has direct implications for the parameterization of convective mixing in numerical models.

TRANSITIONS

None

RELATED PROJECTS

Relatives of these floats are being used in the ONR supported CBLAST study of hurricanes and in studies of circulation, upwelling and mixing off the Oregon Coast.

PUBLICATIONS

Harcourt et al. (2002), Fully Lagrangian floats in Labrador Sea deep convection: Comparison of Numerical and experimental results, J. Phys. Oceanogr., 32, 2, 493-310

Steffen, E. and E. D'Asaro (2002), Deep convection in the Labrador Sea as observed by Lagrangian Floats, J. Phys. Oceanogr., 32, 2, 475-492

Steffen, E. and E. D'Asaro (2002), Meso- and submesoscale structure of a convecting field., J. Phys. Oceanogr., submitted